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Urban soil contamination

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Abstract

Human activity goes hand in hand with urban and industrial development. It leads to the emergence of new industrial technologies, construction materials and techniques. Metropolitan and urban areas are most susceptible to this influence both during the development of new territories and the operation of existing industrial and residential complexes. The article presents the results of the soil investigation conducted in the city of Novokuybyshevsk to determine prospects for future growth of the city. Soil samples were retrieved in the urban area of Novokuybyshevsk in full compliance with the requirements of the State Standard. Soil testing was performed to obtain research data on the concentrations of heavy metals (lead, zinc, copper, cadmium, nickel, manganese etc.), oil, sulfates and nitrates. The findings were then compared with the results obtained in previous years. The research provided a perspective on the current state of the soil, considered major sources of pollution and helped assess the extent of urban soil contamination in Novokuybyshevsk. Realistic and urgent measures were suggested to improve the state of the soil for further development and expansion of the industrial and residential areas of the city.

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*Keywords:*urban areas; soil contamination; investigation; heavy metals; development and expansion

1. Introduction

Urban and industrial development is associated not only with achieving better standards of living and trade growth, but also with the changes in the look of the city due to the expansion of urban and industrial areas [1-4].

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The use of construction materials, machinery and other equipment produces varied construction waste that affects not only the look of the city, but also the quality of urban environment. New plants manufacturing brick, concrete etc., mushrooming shopping malls and multiplexes, the extensive use of cars and heavy-duty vehicles all lead to an increase in the negative impact on urban environment: air pollution, topsoil contamination, surface and groundwater contamination, all made inevitable by urban development.

The understanding that the environment affects people's health and life longevity has led to the emergence of the concept of the environmental safety of residential areas as one of the key factors that are taken into consideration by prospective residents when choosing housing accommodation [5-8]. It is hardly surprising that areas with high levels of pollution are less attractive for the working part of the population [9-13].

Soil is by far the most inert of all natural bodies. There is a constant accumulation of pollutants deposited from the air or brought by surface currents and precipitation.

The aim of this study is to assess the extent of urban soil contamination in Novokuybyshevsk and outline the prospects for further development and expansion of residential areas with satisfactory environmental conditions.

Nomenclature

MPC	maximum permissible concentrations
APC	approximate permissible concentrations

2. Research

Samples were retrieved on the territory of Novokuybyshevsk, one of the developing cities of Russia's Samara region. The investigation was carried out by the Centre of Metrological Support, with the participation of the authors. Soil samples were retrieved in several areas (Figure 1).

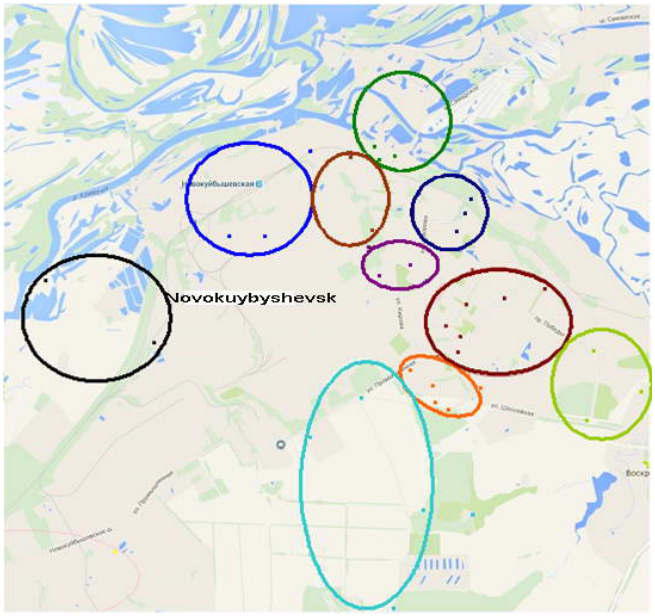

Fig. 1.Soil sampling areas.

Sampling was performed in full compliance with the requirements of the State Standard in nine areas marked on the map. Samples were retrieved in summertime, from the topsoil (up to 10 cm deep, the envelope method). A total of about 50 samples were collected.

Following the retrieval, the Quantum-Z atomic absorption spectrometer was used to test the samples for the presence of the main pollutants: aluminum (Al), cadmium (Cd), manganese (Mn), copper (Cu), nickel (Ni), lead (Pb), zinc (Zn). This method is based on the phenomenon of selective absorption of optical radiation (light) by free atoms of chemical elements.The findings are summarized in table 1.

Table 1.Concentrations of the main pollutants in the soil, mg/kg.

Element	by Area								
	1	2	3	4	5	6	7	8	9
Cu	19.0	15.6	9.3	4.75	4.66	12.33	25.5	27.75	18.85
Pb	13.5	13.2	15.54	12.25	18.66	6.0	10.33	20.5	27.4
Cd	0.43	0.38	0.29	0.18	0.25	0.46	0.45	0.3	0.21
Zn	73.5	62.4	42.1	34.75	58.5	36.3	62.0	61.25	56.58
Ni	16.5	24.6	19.0	35.25	30.0	23.0	25.83	32.5	23.0
Mn	183.3	261.0	227.0	223.0	270.6	155.0	129.0	134.8	125.7
Al	5170.0	7574.0	6230.0	6777.5	4685.0	6566.6	7936.6	6232.5	5232.1

In case there were not any agreed upon MPC values for a specific element, the values obtained were compared with the APC values. The findings were then set against the background reference levels for pollutants in the soils of Samara region (i.e. regional concentration clarkes) to determine the degree of soil contamination inNovokuybyshevsk. The results are shown in the line chart below (Fig. 2).

The investigation has shown that the concentration of copper ranged from 4.66 to 27.75 mg/kg, with the average at 15.3 mg/kg, which did not exceed the MPC value of 55 mg/kg. However, in two areas the values obtained exceeded those of the regional concentration clarke (20 mg/kg) by 27.5% (Group 7 - south-west) and by 39% (group 8).

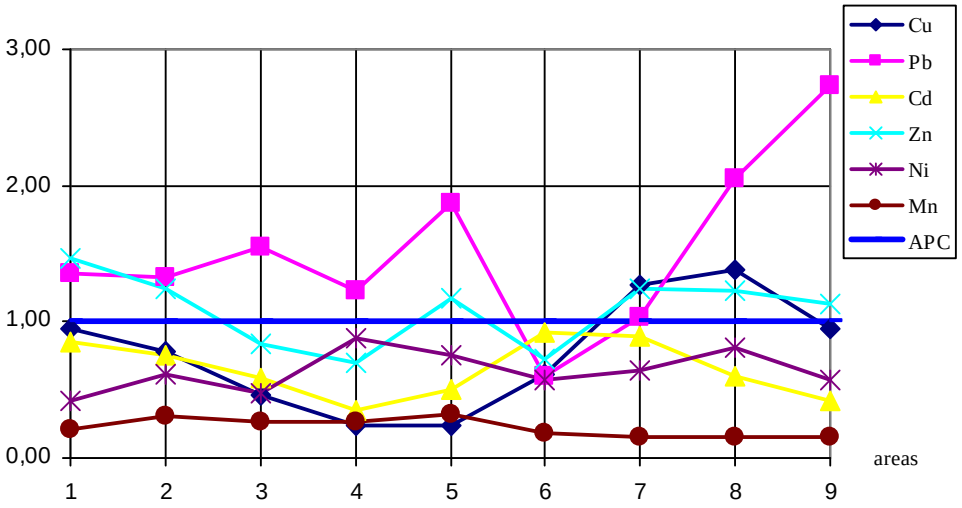

Fig. 2.The concentrations of heavy metals in the soil compared with the APC values.

The concentration of lead ranged from 6 to 27 mg/kg, with the average at 15.26 mg/kg, which did not exceed the MPC value (32 mg/kg), but was 53% higher than the background reference level(10mg/kg). The values of the regional concentration clarke were exceeded in seven areas out of nine.

The concentration of cadmium varied from 0.18 to 0.46 mg/kg, with the average at 0.33 mg/kg. The maximum concentration detected did not exceed the MPV for this element (0.5 mg/kg).

The following zinc concentration values were obtained: the maximum value at 73.5 mg/kg, the minimum value at 36.3 mg/kg and the average value at 54 mg/kg. As the MPC value for zinc is 220 mg/kg, these values were within permissible limits. However, when set againstthe background reference levels (50 mg/kg), the values obtained exceeded the background values by 13-47% in six areas.

The maximum nickel concentration at 35.35 mg/kg did not exceed neither the MPC value (80 mg/kg), nor the regional concentration clarke (40 mg/kg) in any of the areas.

Similar results were obtained for manganese: the maximum value was 270.6 mg/kg, which corresponds to 18% of the MPC value (1500 mg/kg) and to 32% of the regional clarke (850 mg/kg).

MPC and APC values for aluminumhaven't been determined. Therefore, the results obtained were compared only with the background reference levels in Samara region. The concentration of aluminum ranged from 4685 mg/kg to 7936.6 mg/kg, which is 4-6.6 times higher than the background value.

Thus, the findings suggested that the concentrations of lead, zinc and aluminum in all the soil samples exceeded regional concentration clarke values, i.e. the soil is nominally contaminated. As far as the values for cadmium, nickel, manganese and copper are concerned, in most of the samples they did not exceed the values of the regional concentration clarke.

The samples were also tested to determine the concentration of oil, nitrates and sulfates. The following data were obtained.

The amount of nitrates in the samples did not exceed the MPC values (130 mg/kg): the maximum amount of nitrates in the soil was 0.7 MPC. However, the soil samples exceeded 2-10 times the background reference levels for nitrates.

The sulfate content (calculated as sulfur) ranged from 0.15 to 5.1 MPC (160 mg/kg) with the maximum value obtained 15.2 times higher than the background reference levels. The concentration of sulfates exceeded the MPC value in 22% of the samples (more than 2 times the MPC value in 6% of the samples, more than 5 times the MPC value in 2% of the samples).

The average concentration of oil in the urban soil of the city of Novokuybyshevsk was 1005 mg/kg, which is 20 times higher than the background reference levels. The maximum value detected was 6510 mg/kg (130 times the background value). The concentration of oil exceeded the background reference levels in 100% of the samples, with 54% of the samples 5 times exceeding the background value, 38% of the samples 10 times exceeding the background value, 22% of the samples 20 times exceeding the background value, 14% of the samples 50 times exceeding the background value and 6% of the samples 100 times exceeding the background value.

In accordance with the adopted classification of pollution indicators, the soil samples retrieved in the city of Novokuybyshevsk indicate: 1% of the samples –a low level of oil contamination, 10% of the samples –an average level of contamination, 4% of the samples –a high level of soil contamination and 6% – a very high level of contamination.

When comparing the data obtained with the results of a similar research carried out in previous years it has been identified that:

1. On average, the level of oil contamination has remained about the same compared with 1999. The maximum oil concentration was 7,200 mg/kg in 1999. Since then it has reduced by 11%.

2. There has been a significant decrease in the concentration of cadmium, copper, nickel and zinc. In 2005, the maximum value for cadmium was 20 mg/kg, with the average at 3.6 mg/kg. Thus, there has been a 7-10 times decrease in the concentration of cadmium with current numbers below the MPC values. The concentration of copper has decreased from the average of 95.5 mg/kg (the maximum at 527 mg/kg) in 2005 to below the MPC values for most of the urban areas. The concentration of nickel has gone down from the average value of 65 mg/kg and the maximum value of 255 mg/kg in 2005 to 35.5 mg/kg, which does not exceed the MPC either. Likewise, the concentration of zinc has dropped to below the MPC values in all the soil samples retrieved. In 2005, the maximum value was 912 mg/kg, with the average at 275 mg/kg.

3.In 2005, the maximum concentration of lead was 130 mg/kg, with the average at 29 mg/kg. The recent findings indicated a 2-4.5 times drop in the amount of lead. However, the MPC values for lead were exceeded in 14% of the soil samples.

4. There has been an increase in the average concentration of manganese from 250 mg/kg to 270 mg/kg. Despite this, the concentration of manganese in the samples retrieved did not exceed the MPC values.

3. Conclusion

Soil is a valuable resource used in various spheres of human activity. In urban areas there is the biggest negative impact on soils caused by industries, extensive use of transport etc. As a result, topsoil accumulates significant amounts of pollutants. In accordance with existing guidelines the quality of the soil in the city of Novokuybyshevsk was deemed 'permissible' in terms of pollutants concentration (the overall soil pollution index is 4).

The analysis of the soil samples revealed that the central part of the industrial area and the south-west of the city are the least favourable in terms of health and hygiene for prospective residents. Primarily, this is due to the proximity of manufacturing facilities and venues and the dominant direction of airflow that contributes to the spread of pollutants.

It can be concluded that in terms of soil quality south and south-east represent the most favourable areas to extend housing capacity of the city.

References

[1] V.I. Gvozdovsky, S.V. Evdokimov, Environmental Impact Assessment of Project Development and Operation, International Scientific and Technical Conference'Environmental and Hydrotechnical Engineering: Problems of Development, Operation, Environment and Training',SamaraStateUniversity of Architecture and Civil Engineering, Samara, 2014, pp. 219-220.

[2] V.I. Gvozdovsky, M.N. Knyazeva, Environmental State of Natural and Built-in Areas in Construction, International Scientific and Technical Conference'Environmental and Hydrotechnical Engineering: Problems of Development, Operation, Environment and Training',SamaraStateUniversity of Architecture and Civil Engineering, Samara, 2014, pp. 201-203.

[3] V.I. Gvozdovsky, N.S. Sukholitko, M.N. Knyazeva, Chemical and Biological Industrial Pollution, International Scientific and Technical Conference'Environmental and Hydrotechnical Engineering: Problems of Development, Operation, Environment and Training',SamaraStateUniversity of Architecture and Civil Engineering, Samara, 2014, pp. 204-207.

[4] O.I. Marari, Quality of Life in Modern Metropolitan Area: Regional Aspect, Region: Systems, Economics, Management, №4 (15), 2011, pp. 61-65.

[5] I.F. Sukhacheva, L.E. Orlova, O.N. Isakova, L.I. Bedareva, L.V. Pavlova, A.A. Sapukova, T.V. Sudakova, N.M. Toropova, Health and Hygienic State of the Soil in Samara: Possible Risks to Public Health, Proceedings of the Samara Scientific Center of the Russian Academy of Science, №1 (6), 2010,pp. 1516-1523.

[6] V.P. Generalov, E. M. Generalova, Problems of Affordable Housing in Russia, Proceedings of Samara State University of Architecture and Civil Engineering: Urban Planning and Architecture, № 4 (17), 2014, pp. 10-18.

[7] A.V. Zhogoleva, Post-Industrial Urban Planning for Steady Development of Urban Areas, Tradition and Innovation in Construction and Architecture: Urban Planning, Samara, 2015, pp. 54-60.

[8] E.A. Akhmedova, A.V. Zhogoleva, Infrastructure of the Regional Industrial Clusters of the Middle Volga Region (Samara region), Scientific Review, №4, 2015, pp. 178-182.

[9] V.P. Generalov, E.M. Generalova, Comfortable Residential Environment in Modern Urban Development: Problems of Classification, Proceedings of Orenburg State University, №5 (180), 2015, pp. 128-131.

[10] N.A. Lekareva, Spatial Resources of the City, Volga Scientific Journal, №3 (31), 2014, pp. 107-110.

[11] N.A. Lekareva, Urban Planning Management of Valuable Natural Areas, Proceedings of Moscow State University of Civil Engineering, №1, 2010, pp. 28-32.

[12] T.Y. Vavilova, Planning and Development of Multifunctional Industrial and Residential Areas, Volga Scientific Journal, №4, 2009, pp. 100-105.

[13] S.A. Malakhov, E.A. Repina, K.E. Nikonov, Prospects of Urban Planning in Samara, Tradition and Innovation in Construction and Architecture: Urban Planning, Samara, 2015, pp. 160-163.